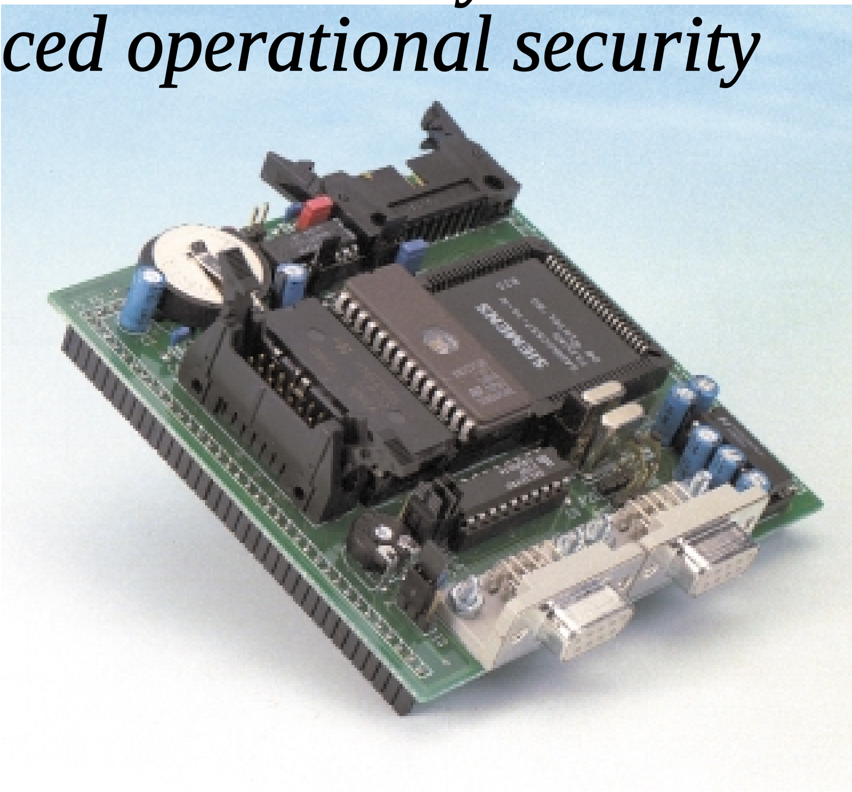
537 ‘Lite’ computer (1)

a high-performance, low-budget core microcontroller system with enhanced operational security

Siemens refers to its top-end 8051 derivative, the 80C537, as the ‘8-bit elephant’. In this article, *Elektor Electronics* presents a low-budget controller board using this microcontroller, as a companion to the previously-published design for a versatile teaching and training system based on the 537. The ‘Lite’ version is intended to be an easily-replaced core system that lends itself to a variety of applications in small to middle-sized projects, and which also satisfies special demands relating to operational security.

Design by Prof. B. vom Berg
and Peter Groppe



Even a superficial glance at the data sheet of the 80C537 microcontroller shows that it truly has a lot of capabilities: an 8(10)-bit A/D converter with twelve inputs, three 16-bit timer/counters with compare/capture features, an arithmetic coprocessor unit, an on-chip watchdog timer, seven bi-directional digital I/O ports, two full-duplex serial interfaces, 14 interrupt sources, low-power modes and lots more. If you want to learn more about this interest-

537 ‘Lite’ computer technical specifications

- *80C537 controller with selectable clock rate (12 or 16 MHz)*
- *enhanced operational security provided by a MAX807 microcontroller supervisory IC*
- *32 kB EPROM and 32 kB RAM, externally expandable to 64 kB each*
- *battery-backed RAM*
- *four free CS addresses (one reserved for LCD module if used)*
- *serial interface 1: RS232 levels; serial interface 2: selectable RS232 or TTL levels*
- *interface for direct connection to an alphanumeric LCD module, 1 x 16 to 4 x 20 characters, with contrast adjustment*
- *three different operating modes*
- *can be programmed in all 8051 languages (via Intel hex files) or using BASIC52 tokenised code*
- *extremely compact construction (90 x 100 mm)*
- *power: 5 V, 75 mA (12 MHz) or 80 mA (16 MHz), exclusive of LCD module*

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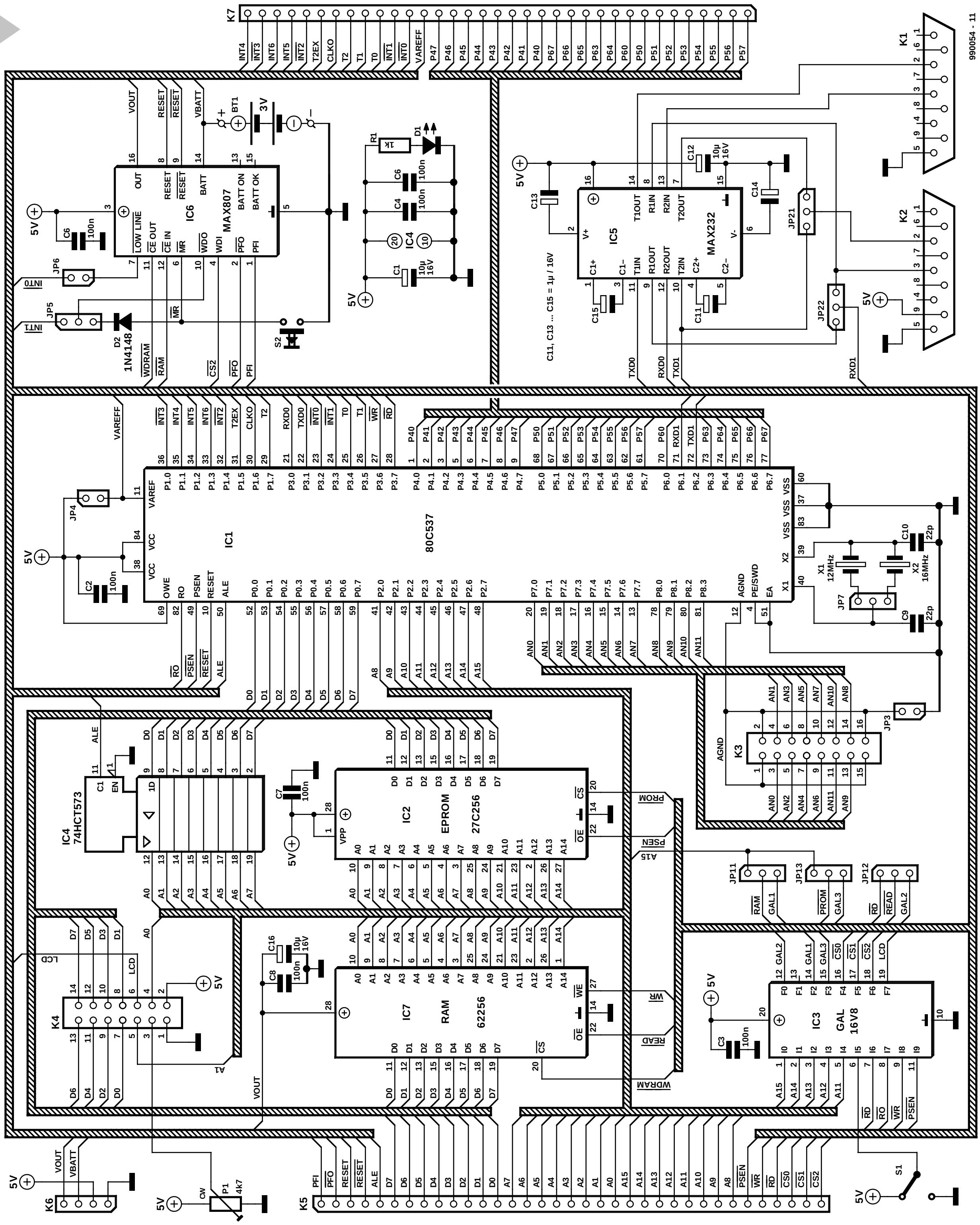

Figure 1. The SAB80C537 is an outstanding microcontroller that forms the heart of a high-performance board.

ing controller, refer to the literature listed at the end of the second instalment of this article.

537 ‘LITE’ COMPUTER HARDWARE

The 537 ‘Lite’ computer board, based on the SAB80C537 processor, represents an inexpensive, universally usable microcontroller system that can be plugged in to an application circuit just like a large IC. The main capabilities of the system are listed in the “537 ‘Lite’ technical specifications” box. All important connections are made via headers or terminal blocks, so that they are available for extension as desired.

The hardware of the board, shown in the schematic diagram of **Figure 1**, can be divided into a number of functional groups.

Controller circuitry

The controller circuitry essentially corresponds to the basic circuit of an 8051-series microcontroller, with the minor difference that two different clock frequencies can be selected via jumper J7.

Digital I/O ports

The digital I/O ports are connected directly to header K7. The inputs do not have any protective circuitry, and the outputs are unbuffered.

Analogue input ports

The 80C537 has twelve multiplexed analogue inputs (0 to 5 V, 8 or 10 bit resolution). These are all connected to K3.

COMPONENTS LIST

Resistors:
R1 = 1kΩ
P1 = 4kΩ7

Capacitors:
C1,C12,C16 = 10µF 16V radial
C2-C8 = 100nF ceramic
C9,C10 = 22pF ceramic
C11,C13,C14,C15 = 1µF 16V radial

Semiconductors:
D1 = LED, 3 mm, red, high efficiency
D2 = 1N4148
IC1 = SAB 80C537-16-N
IC2 = EPROM 27C256 (order code **976510-1**)
IC3 = GAL 16V8 (order code **996515-1**)
IC4 = 74HCT573
IC5 = MAX232
IC6 = MAX807 NCPE
IC7 = 62256 70ns

Miscellaneous:
K1,K2 = 9-way sub-D socket, for PCB board edge mounting
K3 = 16-way boxheader with side latches, straight mounting
K4=14-way boxheader with side latches, straight mounting
K5,K7 = 35-way SIL pinheader
K6 = 4-way SIL pinheader
JP3,JP4,JP6 = 2-way pinheader + jumper
JP5,JP7,JP11,JP12,JP13,JP21,JP22 = 3-way pinheader + jumper
X1= 12 MHz quartz crystal
X2= 16 MHz quartz crystal
S1 = 3-way pinheader for connection to toggle switch
S2 = pushbutton, 1 make contact
BT1 = 3-V Lithium button cell, diameter 20 mm, with holder
PCB, order code **990054-1**
Disk, contains 537 Monitor program, commented, order code **976008-1**

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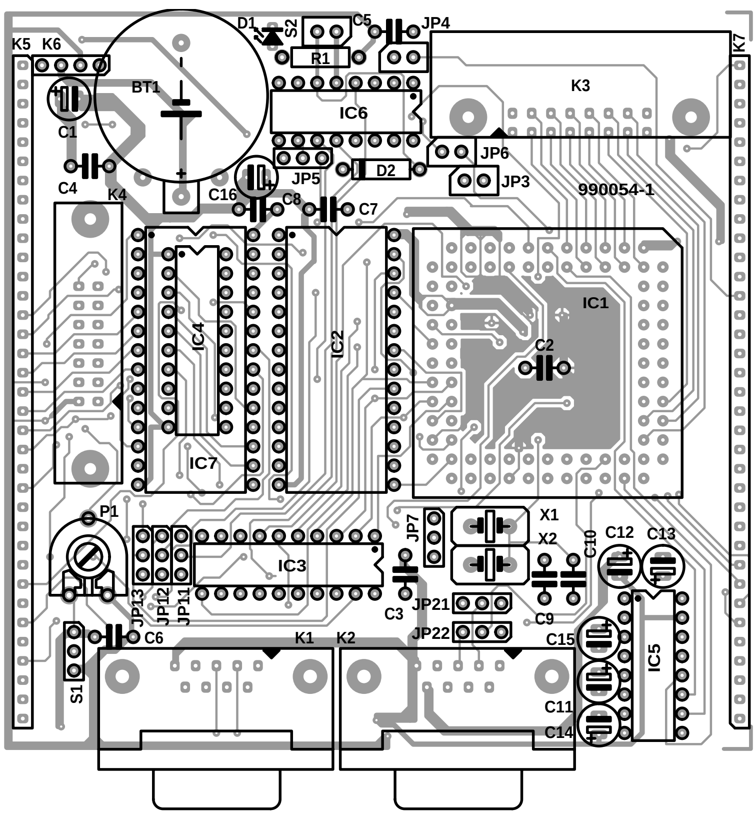


Figure 2. The relatively small printed circuit board can be installed in an application circuit just like a large IC.

Note that external protective circuitry and/or filters may be needed for these inputs. Jumpers J3 and J4 select the connections for the analogue earth (AGND) and the positive reference voltage.

Serial interfaces

The 80C537 has two serial interfaces (SS0 and SS1), which are connected to sub-D sockets K1 and K2. The SS0 interface always works as a V24 interface, using RS232 levels provided by the MAX232 level converter. The SS1 interface can be configured to operate with either V24 or TTL levels by means of jumpers J21 and J22.

Memory banks

The memory ICs (IC2, a 32 kB EPROM and IC7, a 32 kB RAM) are connected in the usual 8051-series manner via Port0 and Port2 of the controller, with the aid of a 74573 address latch (IC4).

Decoding logic

The necessary logic circuitry for encoding or decoding control signals is housed in a GAL 16V8 (IC3) in order to save space.

LCD module

An alphanumeric LCD module can be connected directly to connector K4, as long as the module has a Hitachi HD44780 controller or a compatible type (which is true of 80% of all such modules). This allows the 537 'Lite' board to be used directly with display modules ranging from one row of 16 characters to four rows of 20 characters. The display contrast can be adjusted using preset P1.

Microcontroller supervisory IC MAX807

The outstanding operational security of this microcontroller system is provided by the special-purpose MAX807 IC. This IC supports seven important and essential monitoring, reporting and alarm functions in the microcontroller system, as follows:

- automatic power-on reset generation;
- manual reset generation via a pushbutton switch;
- watchdog timer;
- chip-enable protection in case of system voltage failure;
- system voltage monitoring;
- power supply voltage monitoring;
- battery-backup connection with battery management.

A detailed description of this IC may be found in the datasheets to be published in next month's magazine.

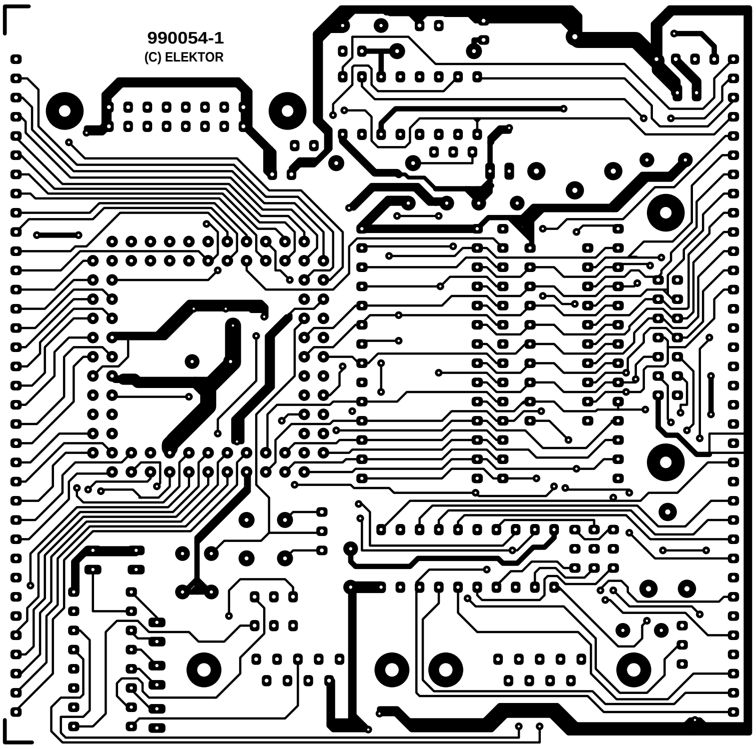
CONSTRUCTION AND INITIAL OPERATION — IT'S EASY!

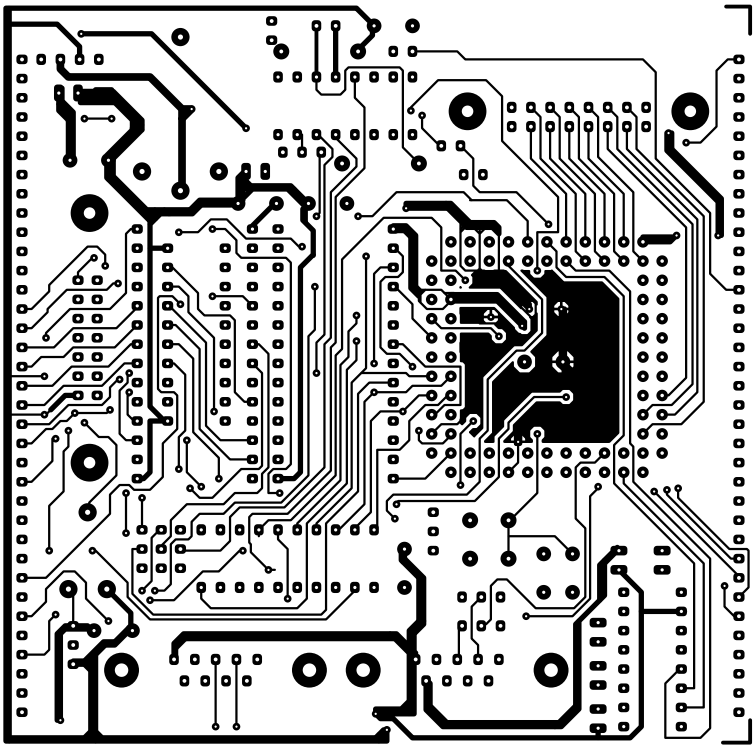
When constructing the circuit board, as shown in **Figure 2**, follow the well-known rules: fit the small components first and then the larger ones, use high-quality sockets for all ICs, and carefully inspect the board after completing the soldering. The backup battery should only installed at the very end, after initial operation has been successfully completed.

The memory ICs IC4 and IC7 are mounted 'piggy back' in order to save space. This mounting method is not as unusual as it may seem. Since sockets are used for both ICs, either a set of extra socket strips or an additional 28-pin socket with the middle portion cut away must be used to elevate the RAM IC (IC7).

After performing a final inspection of the components and installing the monitor EPROM IC2, set the basic configuration of the jumpers for operating mode 2, Program Download, as follows:

- set jumpers J11, J12 and J13 to position 2-3;
- set jumpers J21 and J22 to position 1/2;
- install jumpers J3 and J4;





- remove jumpers J5 and J6;
- set jumper J7 to position 1-2 (12 MHz clock);
- set switch S1 to the Load RAM position (grounded).

Now connect the supply voltage. *Tip:* during initial testing, do not connect the power supply leads directly to header K6 (that is, by soldering and subsequently unsoldering them), but instead supply the board with power via sub-D connector K2 (pin 5 = earth and pin 9 = +5 V). The operating voltage must be exactly 5 V, and it must not be connected with the wrong polarity! The current consumption should not exceed 80 mA.

After this, switch off the supply voltage and connect the SS0 interface on the board (K1) to a free COM interface of the PC. You can easily prepare the necessary cable yourself, as follows:

K1 (537-Board)	**PC (AT)**
Sub-D9	Sub-D9
TXD 2	RXD 2
RXD 3	TXD 3
GND 5	GND 5

If the board is to be connected to an old XT PC, the TXD and RXD connections must be swapped at the PC, and in addition the GND connection is on pin 7 of the 25-pin sub-D connector of the XT:

K1 (537-Board)	**PC (XT)**
Sub-D 9	Sub-D 25
TXD 2	RXD 3
RXD 3	TXD 2
GND 5	GND 7

Now you can again switch on the power for the 537 Lite board. The current consumption should not be any greater than before.

In order to establish communications with the board, go to the DOS level and insert Elektor diskette no. **976008-1** in drive A. First run the disk fingerprint check, `CHECK 1`. Now launch Windows and then HyperTerminal or another general-purpose communications program like ProComm or Telix. Use these settings: 9600, N, 8, 1, no flow control, and be sure to use a communication port that is still available for the 537 'Lite' Computer.

If you press the reset switch on the 537 'Lite' board, it will respond with the message `TFH 80C537er Monitor` ('TFH' stands for 'Technische Fachhochschule Georg Agricola in Bochum').

The link between the PC and the 537 board has now been established, and the first program may be downloaded. A reset, as just described, must be executed before every download of a new program. Once a program has been downloaded, press the reset button to return to the start of the program and then enter `g0` to start the program.

In order to download a program, press the F2 key (Input from file), enter `p1.hex` as the input file name, and confirm the entry by pressing <Return>. A number of columns of numbers will flit over the screen; these represent the Intel hex file of the `p1.hex` program. A hash sign will appear again to mark the end of the download.

After `g0` <Return> has been entered, the program starts at address 0. S1 should be in the Load RAM position. The microcontroller board will then greet you most cordially.

(990054-1)

Design editing: K. Walraven

Part 2 of this article, in the February issue, deals with programming the 537 'Lite' board. It also describes some possible extensions. Details on connecting the board to a CAN bus appear elsewhere in this issue.